§14. H-Mode Transition in Deuterium Plasmas Triggered by Modification of Edge Magnetic Field Structure

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We discovered the H-mode like phenomena in hydrogen plasmas heated by neutral beam injection(NBI) when the plasma current was driven to increase external rotational transform ι_{ext}[1]. The discharge behaviors are very similar to the H-mode in tokamaks, that is, formation of edge transport barrier, improvement of particle and energy confinement times and so on. In this discharge, however, the depression of Hα-light across the transition is not significant and occurs relatively slow(comparable to the energy confinement time τ_E), while electron density profile near the edge measured by thermal Lithium beam probe(LIBP) evolves to the profile with steep gradient near the edge rapidly (less than τ_E). The back(H-L) transition is unclear.

Recently, we have observed the H-mode with very fast transition in deuterium plasmas through the above-mentioned operation scenario, as shown in Fig.1[2]. Across the L-H transition, the Hα-light is depressed very rapidly (less than 0.2 ms), of which time scale is much less than τ_E. Moreover, the back(H-L) transition is also very clear. We have confirmed the formation of edge transport barrier through profile measurements of electron density, electron temperature and ion temperature. The LIBP measurement clearly shows that electron density just outside the last closed flux surface (LCFS) is decreased within 0.2 ms at the transition and just inside LCFS the density is increased with the short time scale. This indicates the rapid formation of the transport barrier. Across the transition electron density fluctuations near the edge are clearly suppressed in the range of more than 50 kHz. The low frequency fluctuations are increased, suggesting the excitation of MHD modes related to ι=1 surface. In the H-phase, the increase of the radial electric field shear near the edge is seen from impurity rotation measurement. The estimated radial electric field is comparable to that observed in high density CHS plasmas.

We have studied the threshold conditions. The transition is initiated at the threshold plasma current which sensitively depends on the toroidal magnetic field and $\iota_{ext}(a)$ at LCFS. According to the magnetic configuration calculated by the VMEC code, the transition seems to occur when the ι=1 surface appears near the edge but inside LCFS (<r>/<a>~0.9). We also have found the threshold NBI power under the condition that the toroidal magnetic field, plasma current and target electron density are fixed. We are studying the isotope effect on the transition in hydrogen or deuterium plasmas.

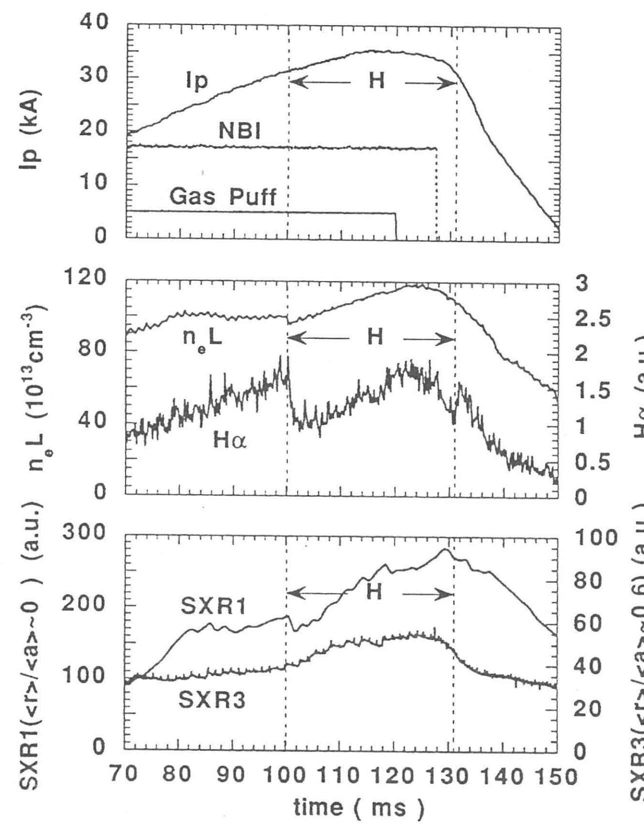

Fig. 1 Time evolution of plasma current, line averaged electron density of the central chord, Hα-light, and soft X-ray emissions at <r>/<a> ~ 0 and 0.6 in the H-mode plasma, where Bt~1.2 T and absorbed NBI power~0.5 MW.

1) Toi, K. et al., in Plasma Physics and Controlled Nuclear Fusion Research 1993(Proc. 14th Int Conf. Würzburg, 1992), Vol.2, p461.
2) Toi, K. et al., in Plasma Physics and Controlled Nuclear Fusion Research 1994(Proc. 15th Int Conf. Seville, 1994), paper IAEA-CN-60/A6/C-P-3.